HYSPLIT Dispersion Model Upgrade V7.2.0

EMC CCB Meeting

14 May 2014

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Charter Overview

This project is an NWS and NCEP milestone for Q4FY14

HYSPLIT description : Current Operational Dispersion Products

- 48-hour wild-fire smoke forecasts (06 UTC cycle) for CONUS, AK, HI
- 48-hour dust forecasts (06 and 12 UTC cycles) for CONUS
- 48-hour volcanic ash forecasts whenever requested by the ICAO-designated U.S VAACS (Washington, DC, Anchorage, AK).
- 72-hour radiological emergency response plume forecast when requested per the WMO-RSMC arrangements (IAEA or other country's NMS).
- 48-hour back-tracking product when requested per the WMO/RSMC arrangement
- 16-hour dispersion forecast for HAZMAT-type (chemical spill, explosion, etc.) incident upon the request of a WFO; and for about 25 pre-determined locations 4x/day

Charter Overview

Overview of Changes in Version 7.2

- **ALL –** Update to **unified HYSPLIT** code and libraries

- **CTBTO** – New application & NCO web GUI for model configuration
  – Extend retention of **GDAS/GFS ARL packed** format files
  → /com/hysplit **to 30 days**

- **Volcanic Ash –** Add ½ ˚ **GFS** hysplit format files

- **RSMC**
  – radiological text product to MWOs (AWC, Anchorage and Honolulu)
  – Add ½ ˚ GFS hysplit format files

- **WFO Hazmat –** Improved Google Earth Graphics (NCO is backup)

- **Smoke –** Include **Canadian & Mexican** emissions

- **Dust –** No specific changes

Charter Overview

Expected Benefits to End Users

- **ICAO and FAA** – via NWS/ASB – radiological advisory product accessible to Meteorological Watch Offices

  (NCEP AWC, Anchorage and Honolulu WFOs)
- **WMO-RSMC** – updated nuclear power plant latitudes-longitudes
- **CTBTO** – new requirement
- **NWS WFOs/HAZMAT** – improved Google Earth graphics

- **Simpler version control** by re-compiling all code with the same (updated) HYSPLIT library
- **Consistency** of all NCEP HYSPLIT dispersion applications running the same code
- Better able to simulate dispersion for with the **higher-resolution GFS**
- Use of a **new web-based SDM interface** for the CTBTO back-tracking application (NCO transitioning with ARL)
- **Implement** smoke and dust satellite based verification.

Development testing

- HYSPLIT V7.2 run at ARL for 4 months
  - ARL runs:
    - DATEM experiments (details follow) to compare boundary-layer dispersion model output to measurements.
    - "TEST" job for volcanic ash, RSMC, WFO-request
- Built and tested at EMC since Feb. 2014
  - EMC Frozen parallel on March 2014
- EMC Real-time and Retrospective Parallels
  - Smoke: July 8 – Sept. 15, 2013
  - CTBTO: December, 2013 - May 2014
  - smoke/dust with parallel NAM – Feb-May 2014

Recommended length of time for official evaluation parallel:

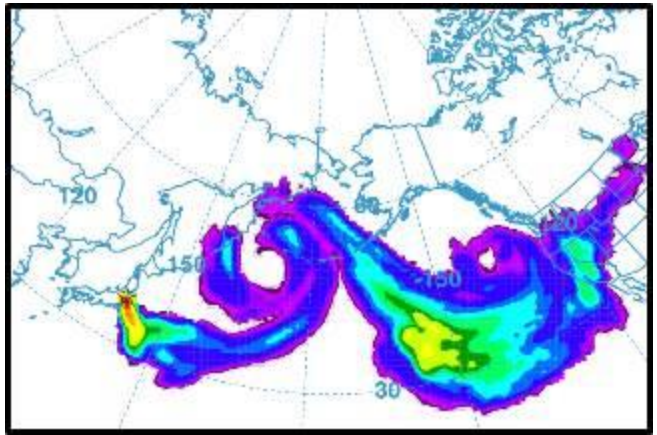
30 days (except CTBTO given rarity of events to begin June 2014, ~ 2 events per month)

Testing Summary

- ARL Retro field experiment tests (DATEM) show similar performance
- *CTBTO* testing results same as ARL with updated HYSPLIT
- *Extensive smoke and dust testing* → positive impact w/ CA/MX emissions
- *Volcanic ash – 2010 case*
- *RSMC radiation -> Fukushima case*

EMC PARALLEL EVALUATIONS

- Smoke/Dust: NESDIS & EMC evaluated parallel runs
- CTBTO: running in parallel and compared to ARL parallel cases
- EMC and ARL web sites for displays



DATEM – Data Archive of Tracer Experiments and Meteorology

http://www.arl.noaa.gov/DATEM.php

- Database for verification of boundary-layer dispersion:
  - Many tracer releases (CAPTEX, ETEX, etc.)
  - Various horizontal scales (5 km to 3000 km)
  - Various meteorological situations
  - NARR used for in older experiments (pre 2000)

- Updated HYSPLIT v7.2.0 and prod v7.0.3 comparison:
  - performance is about the same.

Courtesy, NOAA/ARL

DATEM – Data Archive of Tracer Experiments and Meteorology

v7.2.0 compared to v7.0.3

Experiment	Corr	FB	FMS	KSP	Rank	Rank
ACURATE	0.90	0.34	100.00	20.00	3.44	3.45
ANATEX_GGW	0.97	-0.04	97.37	50.00	3.40	3.47
ANATEX_STC	0.41	0.52	97.33	39.00	2.49	2.46
CAPTEX	0.75	-0.08	96.15	13.00	3.35	3.36
ETEX	0.67	0.54	75.00	17.00	2.75	2.55
INEL74	-0.09	0.23	100.00	54.00	2.35	2.46
METREX_8h_MDVA	0.57	0.13	71.98	6.00	2.92	2.92
METREX_8h_MtVernon	0.37	-0.41	84.32	12.00	2.65	2.64
OKC80	0.59	0.07	51.16	43.00	2.40	2.41

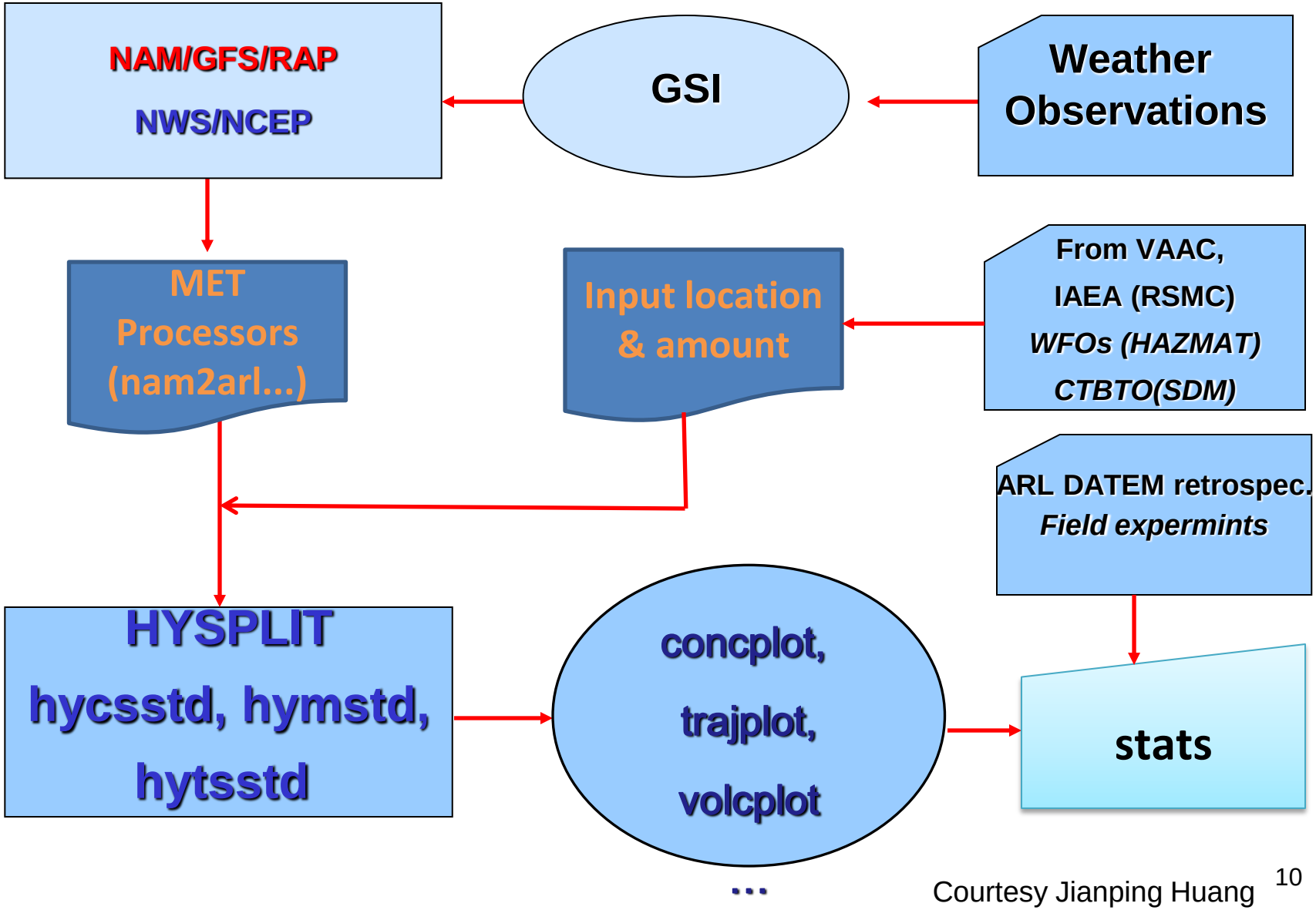
better

Net result –
about the same

Rank from 0.0 (worst) to 4.0 (best), changes ≤ 0.1 are not significant

Courtesy, NOAA/ARL

HYSPLIT On-Demand Forecasting System (Volc ash, RSMC, HAZMAT)

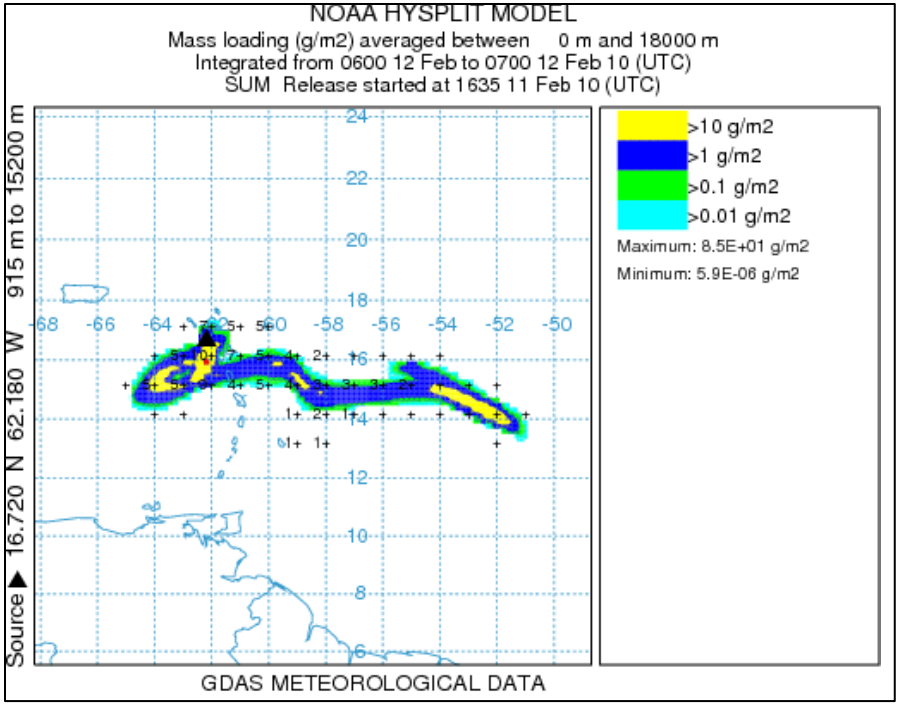


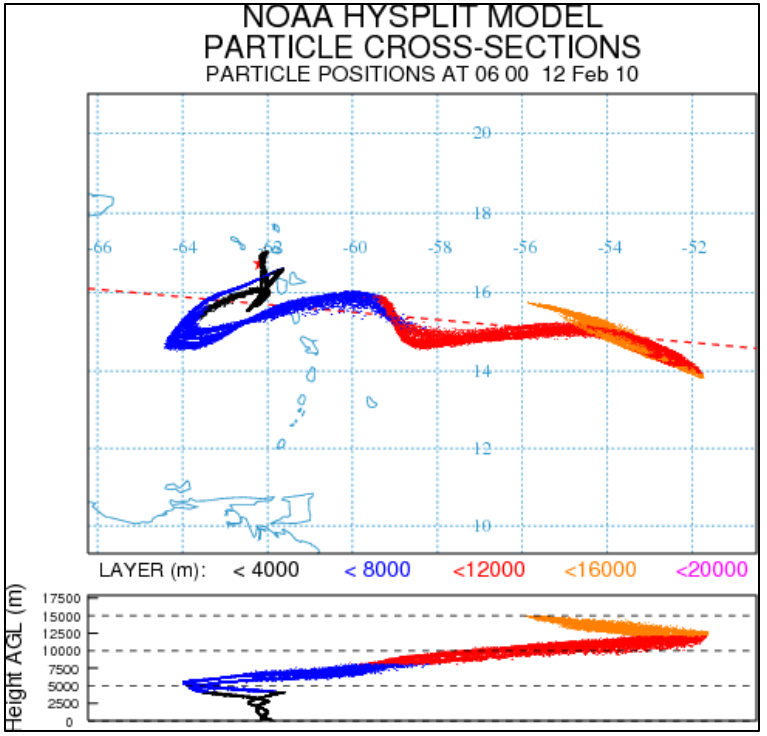
Courtesy Jianping Huang

Volcanic ash Evaluation

Soufriere Hills, Montserrat, West Indies

- within Washington, DC, Volcanic Ash Advisory Center's response area
- February 12, 2010, 1-h eruption to 15 km (50,000 ft)





Shaded areas, HYSPLIT mass loading
Plus symbols outline satellite-detected* ash,
with mass loading >0 shown

HYSPLIT.v7.2.0

*Pavolonis, Michael J. et al. (2013). Automated retrievals of volcanic ash and dust cloud properties from upwelling infrared measurements. Journal of Geophysical Research-Atmospheres, Volume 118, Issue 3, doi:10.1002/jgrd.50173.

Courtesy, NOAA/ARL

Volcanic ash Evaluation

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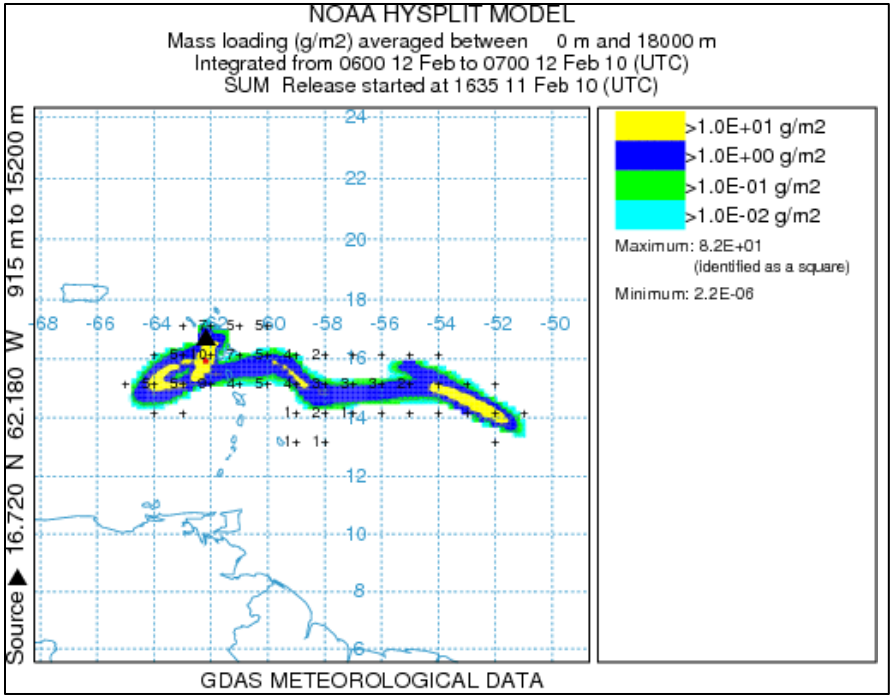
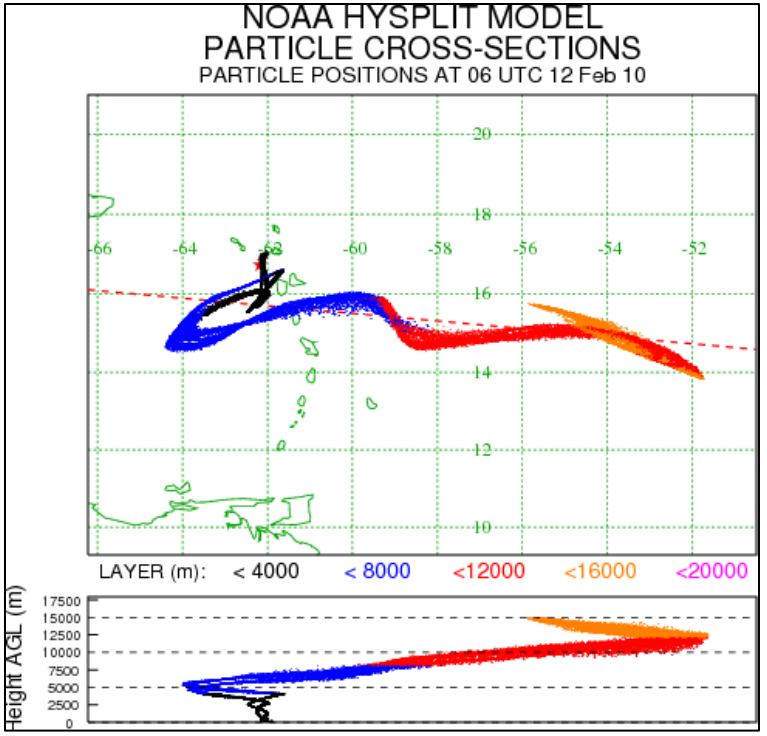




Nearly identical graphics v7.2.0

HYSPLIT.v7.0.3

Courtesy, NOAA/ARL

Volcanic ash Evaluation

Soufriere Hills, Montserrat, West Indies

- Graphics nearly identical results v7.2.0 and v7.0.3
- Statistical comparison against satellite-based mass loadings show no significant differences.

	V7.2.0	V7.0.3
Correlation Coefficient	0.33	0.34
Fractional Bias	0.25	0.23
Figure of Merit in Space	48.15	48.15
KSP*	26.00	26.00
Rank	2.21	2.22

KSP = Kolmogorov-Smirnov Parameter

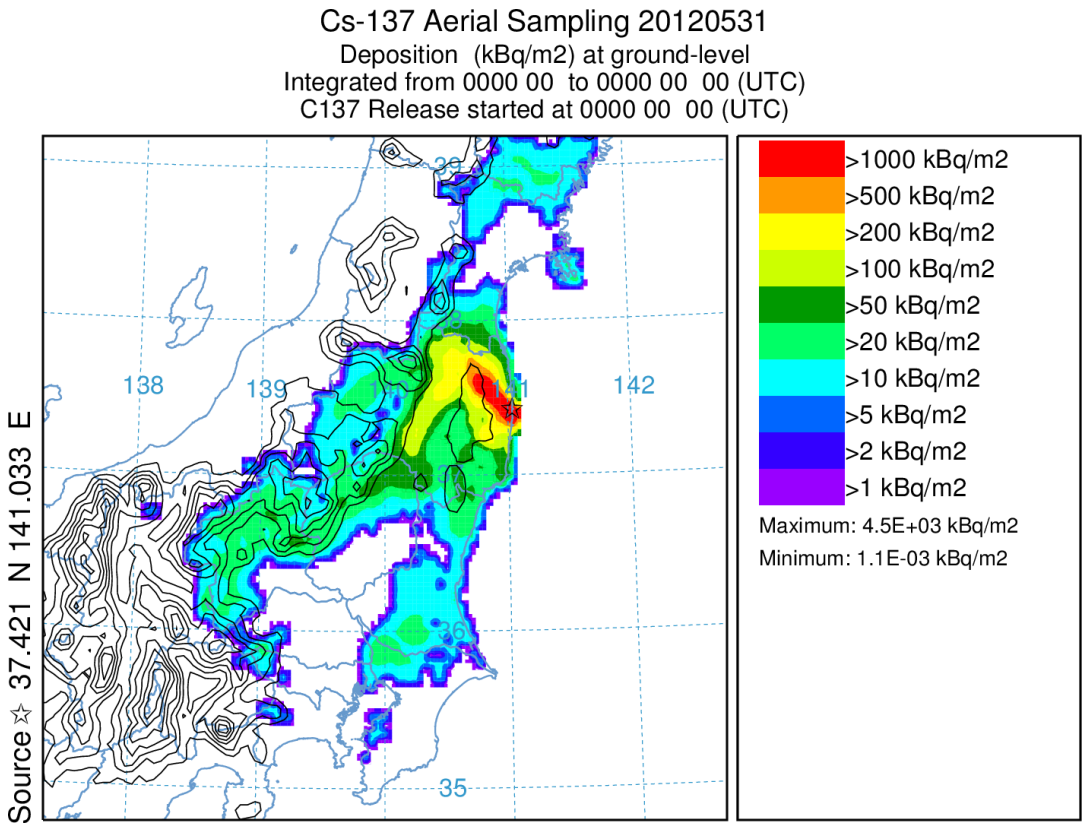
Courtesy, NOAA/ARL

Radiological (RSMC/HAZMAT) Evaluation

Fukushima-Daiichi Nuclear Power Plant, March 2011

Measured Deposition

- Measurements were taken one year after the accident.
- The bulk of the deposition shown to the northwest of the FDNPP was the result of a single event that occurred between 14-16 March 2011.
- Note the lack of deposition over the Kanto plain toward Tokyo and the constraints provided by the mountains to the west.



The measured deposition pattern for Cs-137 is shown here in color interpolated to the HYSPLIT 5-km resolution deposition grid.

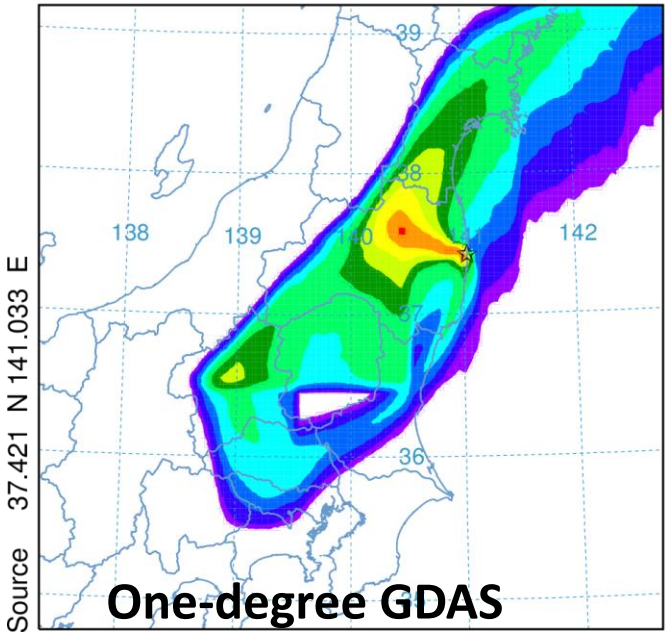
The black contours show the terrain features at 250 m intervals.

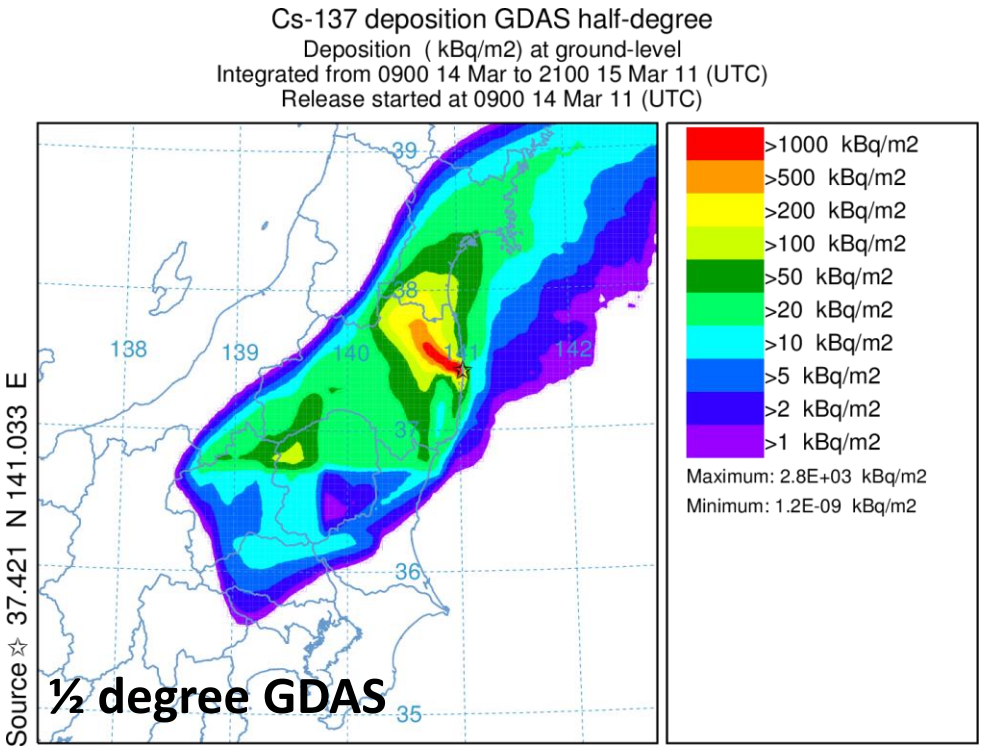
Courtesy, NOAA/ARL

Radiological (RSMC/HAZMAT) Evaluation

Fukushima-Daiichi Nuclear Power Plant Accident

Cs-137 deposition for emissions only 14-15 March 2011





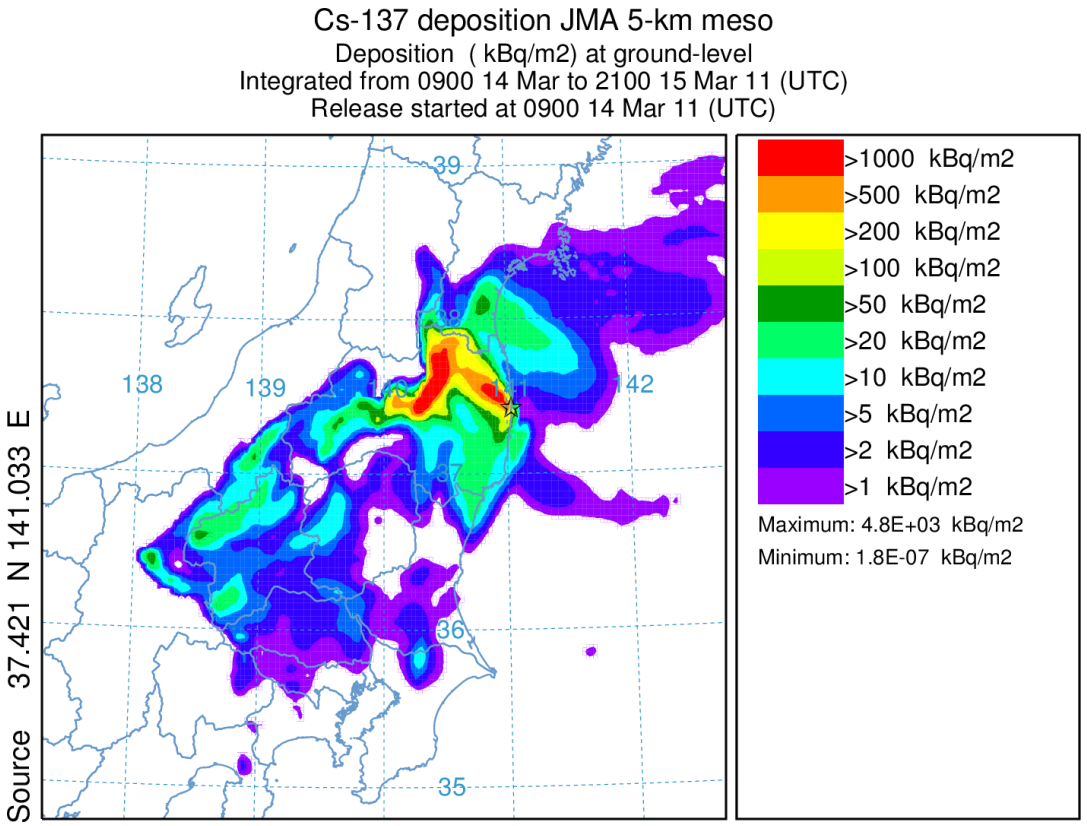
- Lacks the detailed structure and underestimates maximum deposition region to the northwest of FDNPP.
- High deposition region turned more to the south than shown in the measured pattern.

- Structure is very similar
- Maximum deposition and direction of the high deposition region are almost identical to measured.
- Rectangular deposition structure to the south:
  - deposition : strong sensitivity to wet removal processes & resolution of precipitation fields.

Courtesy, NOAA/ARL

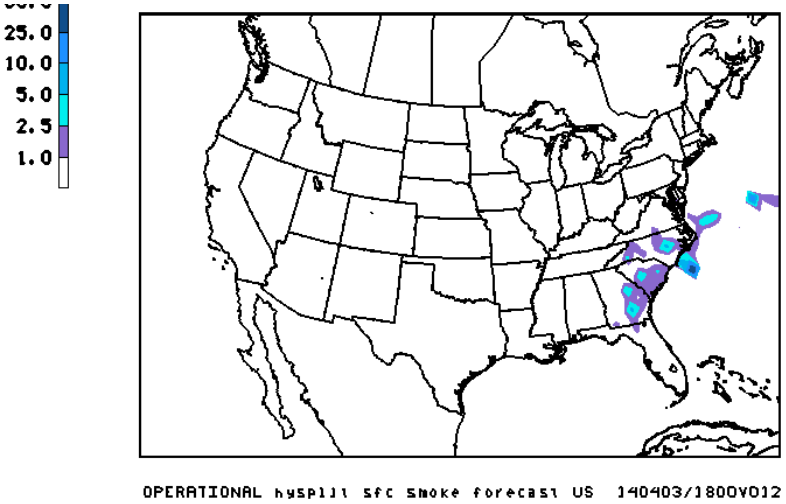
JMA 5-km mesoscale

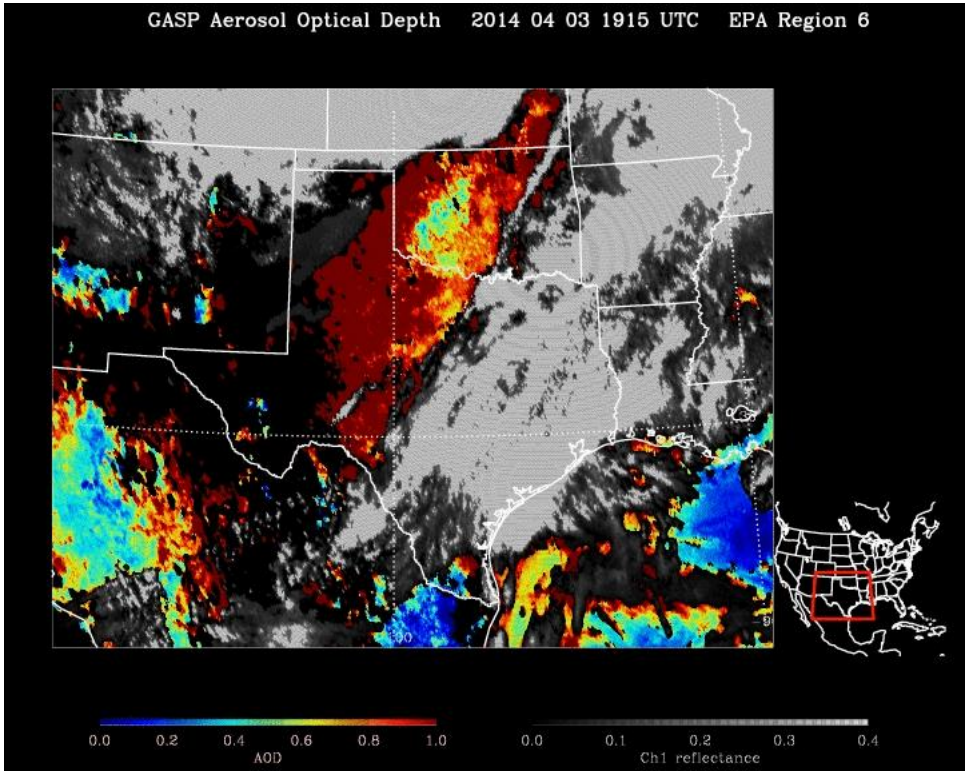
For reference, the Cs-137 deposition pattern shown here was computed using the 5-km resolution mesoscale analysis from the Japan Meteorological Agency. Although the calculated deposition pattern shows more structure than the other calculations, the adjacent high and low values do not compare favorably with the smoother measured pattern. However, this calculation does capture the "elbow" pattern in the high deposition region, although the values are over-predicted. This over-prediction is believed to be due to the fact that wet removal in the mountain regions was primarily in the form of snow, which is less efficient than removal by rainfall. Future HYSPLIT revisions will account for different precipitation types.



Courtesy, NOAA/ARL

HYSPLIT Wild fire Smoke Application





NESDIS GASP Imagry of fire smoke on April 3, 2014.
Smoke primarily from Mexican fires not included in operational HYSPLIT Smoke forecast system.

HYSPLIT Smoke Forecasting System

NMM-B/GFS
NWS/NCEP

GSI

Weather Observations

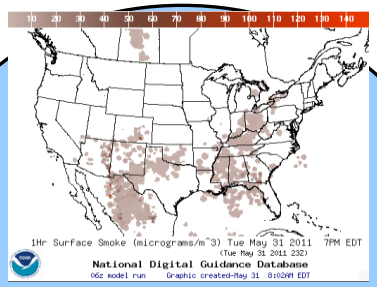
MET Processors

BlueSky USFS

HMS Smoke & Fire detection NOAA/NESDIS

GOES Smoke NESDIS

HYSPLIT
OAR/ARL, NWS/NCEP



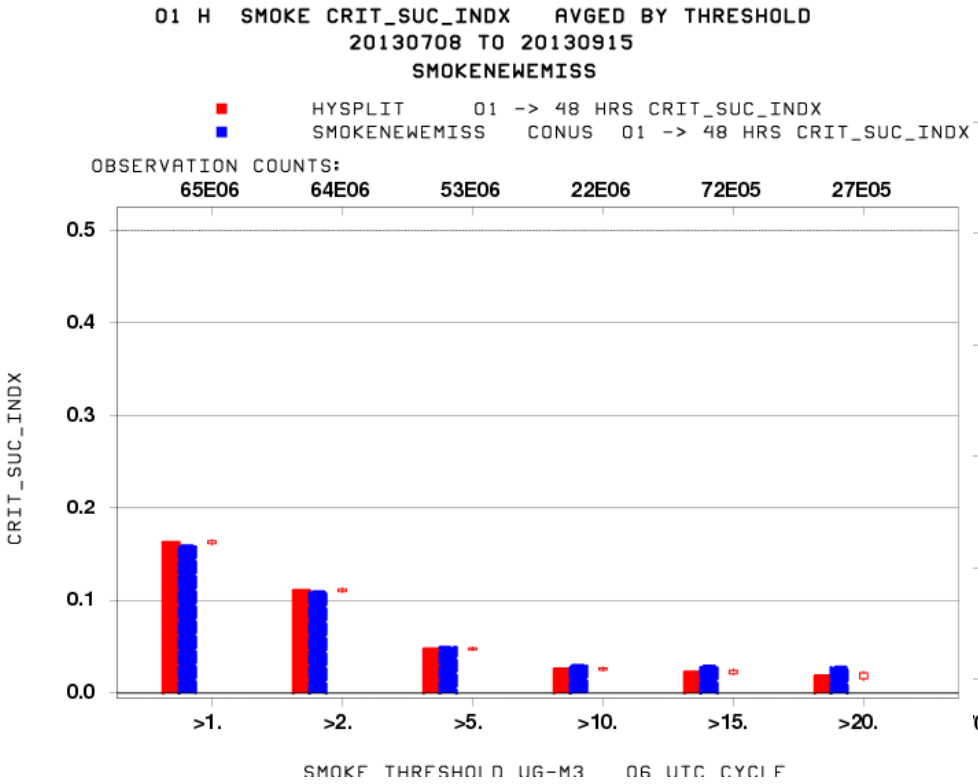
+ HI, AK

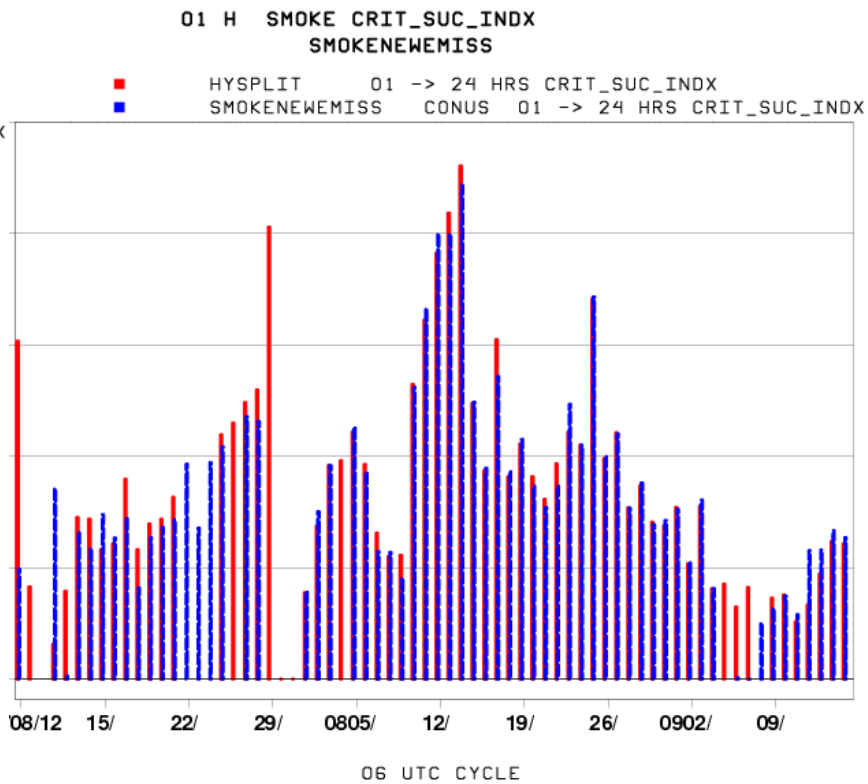
G2G FVS
NWS/NCEP

Courtesy Jianping Huang

Canada/ Mexico Emission impact

July 8 – Sept. 15, 2013 CONUS CSI verification





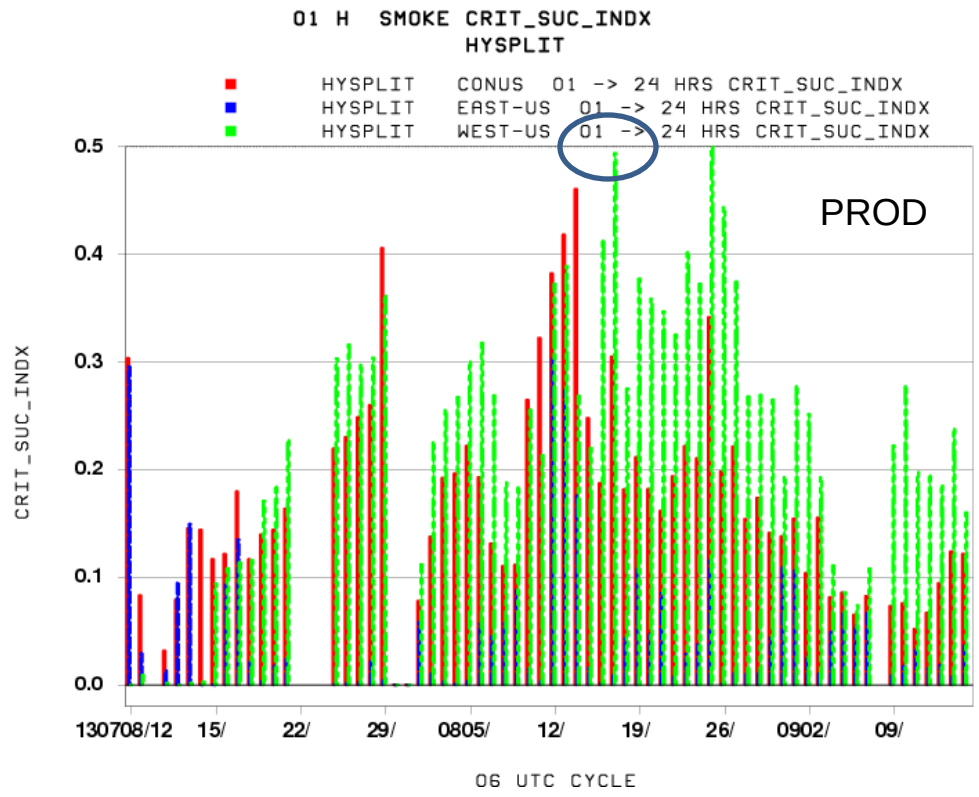
http://www.emc.ncep.noaa.gov/mmb/aq/fvs/hysplit/web/html/fho.html

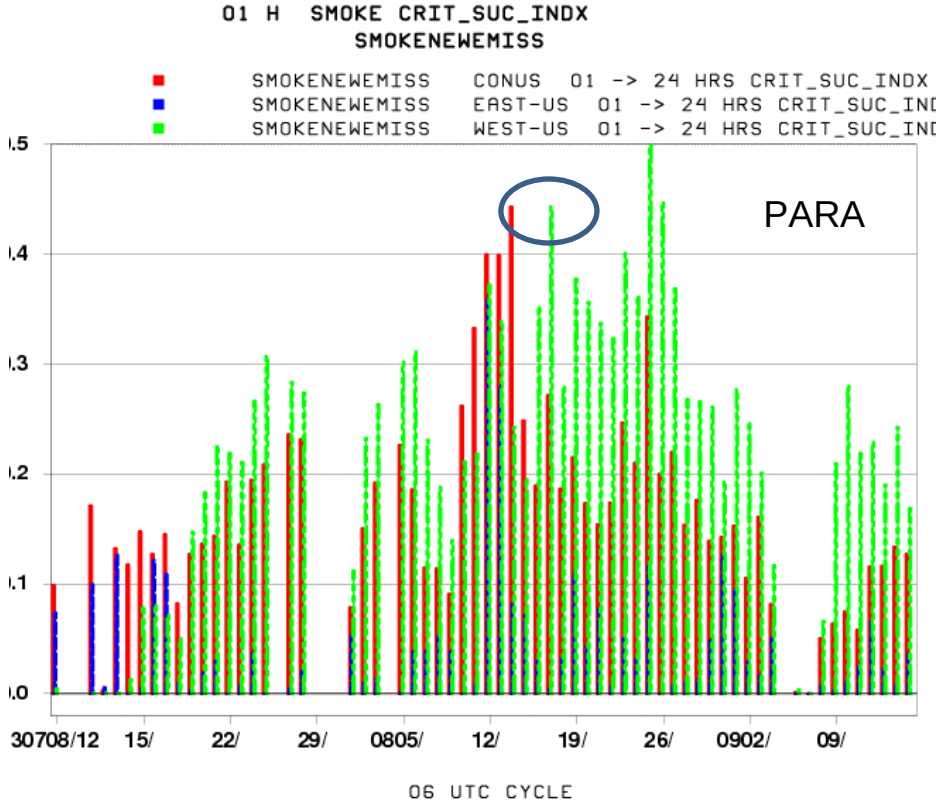
Using NDFD 5 km G227 model output grid

- Now 7 days missing from parallel run
- Slight improvement for >10 ug/m3 thresholds
- Similar for low smoke thresholds

Canada/ Mexico Emission impact

July 8 – Sept. 15, 2013 CONUS, East, West Regions

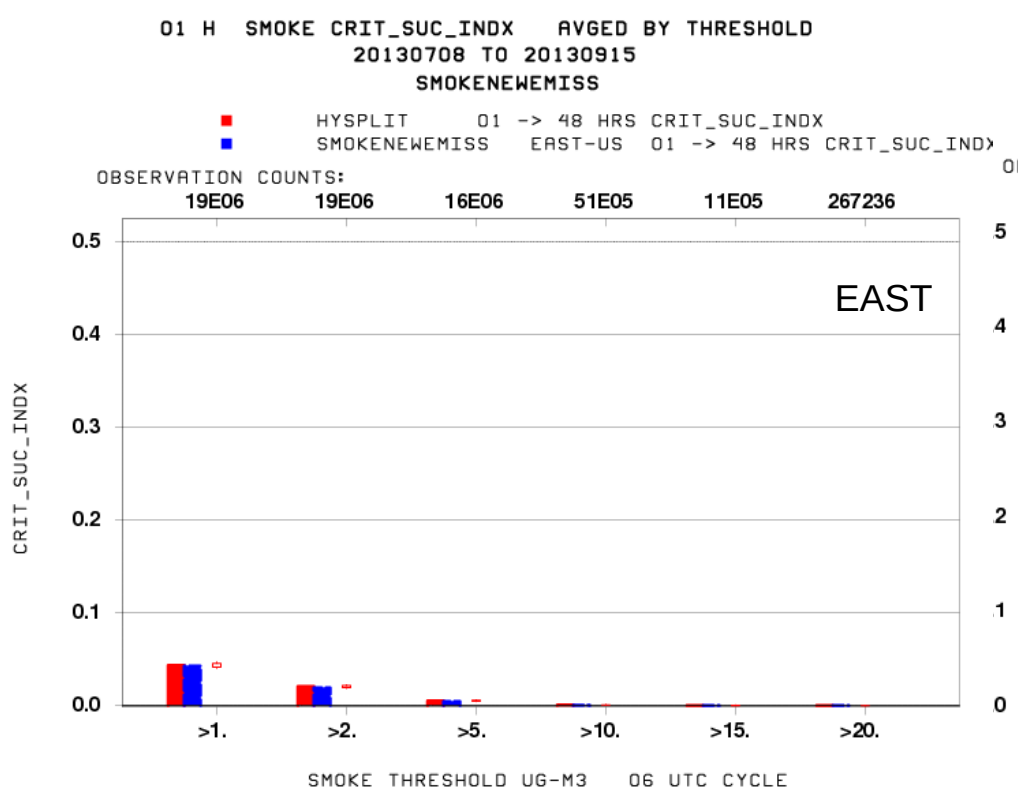


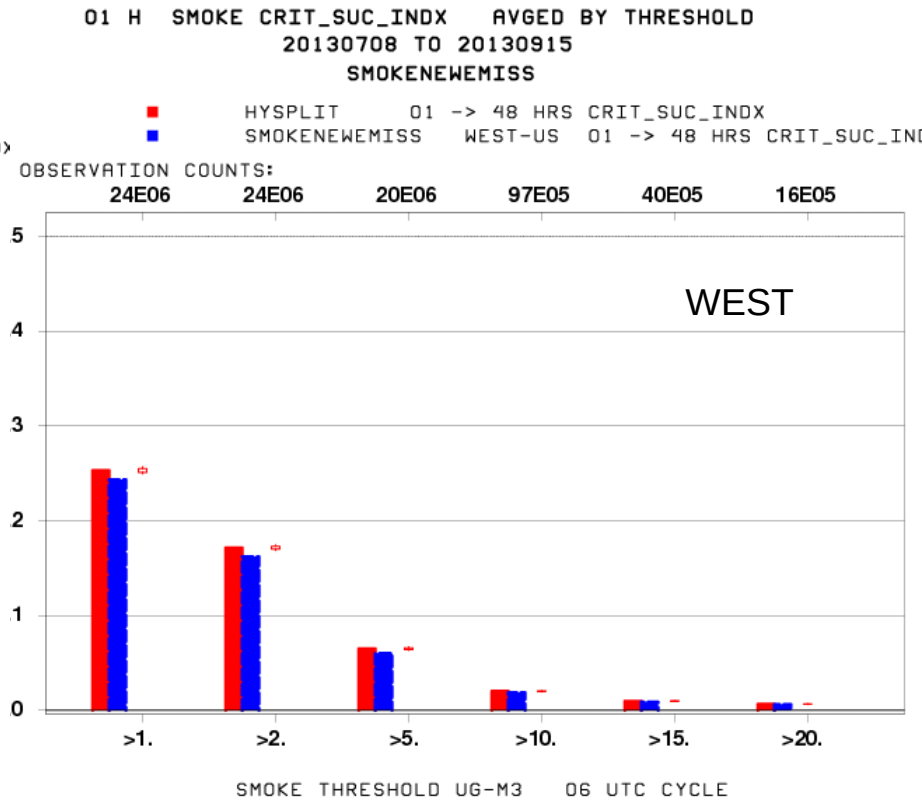


- http://www.emc.ncep.noaa.gov/mmb/aq/fvs/hysplit/web/html/fho.html
- Some impact in Western Region

Canada/ Mexico Emission impact

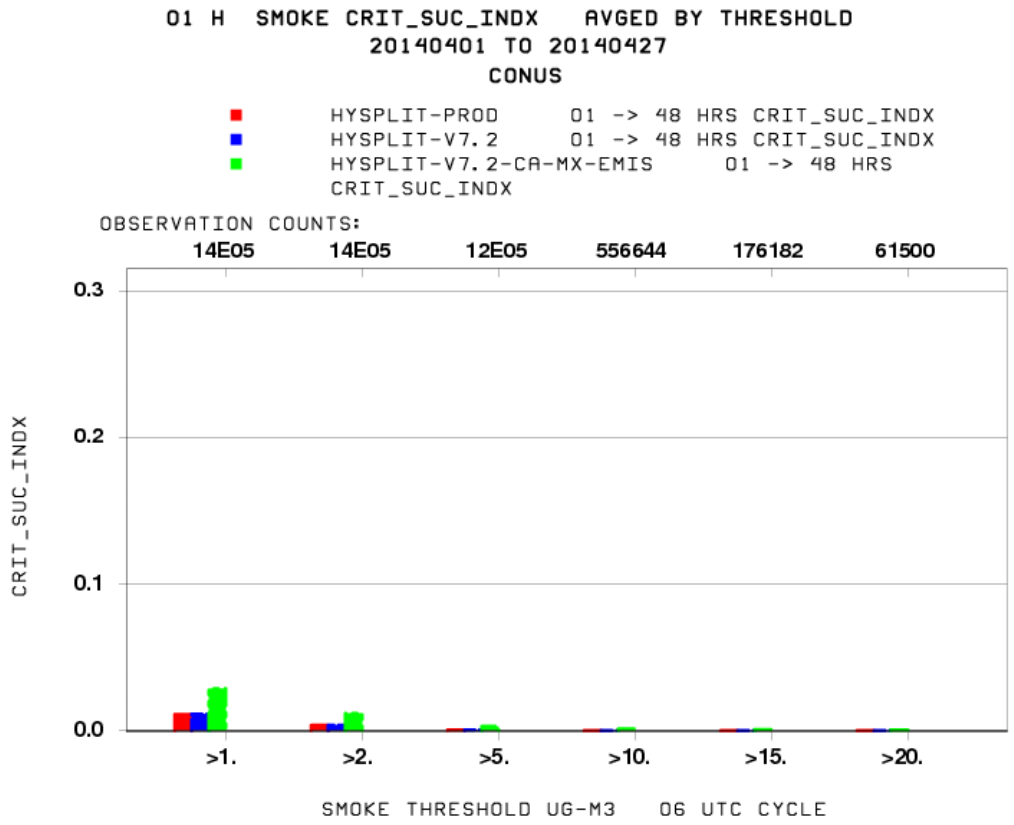
July 8 – Sept. 15, 2013 East and West Regions

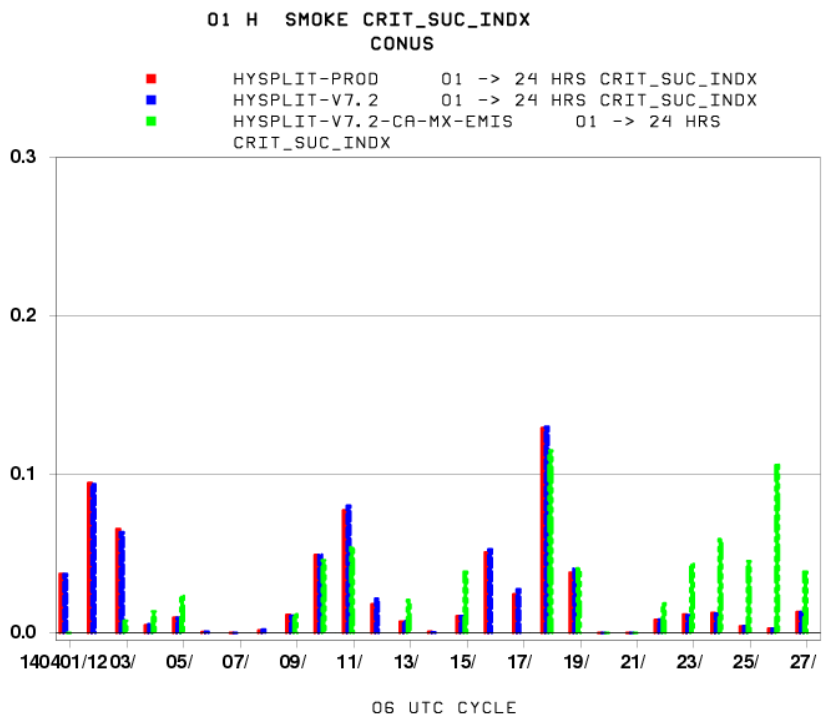




- http://www.emc.ncep.noaa.gov/mmb/aq/fvs/hysplit/web/html/fho.html
- Degraded forecast for low smoke concentrations (< 5 ug/m3) from PARA

Canada/ Mexico Emission impact
April 2014 CONUS CSI verification





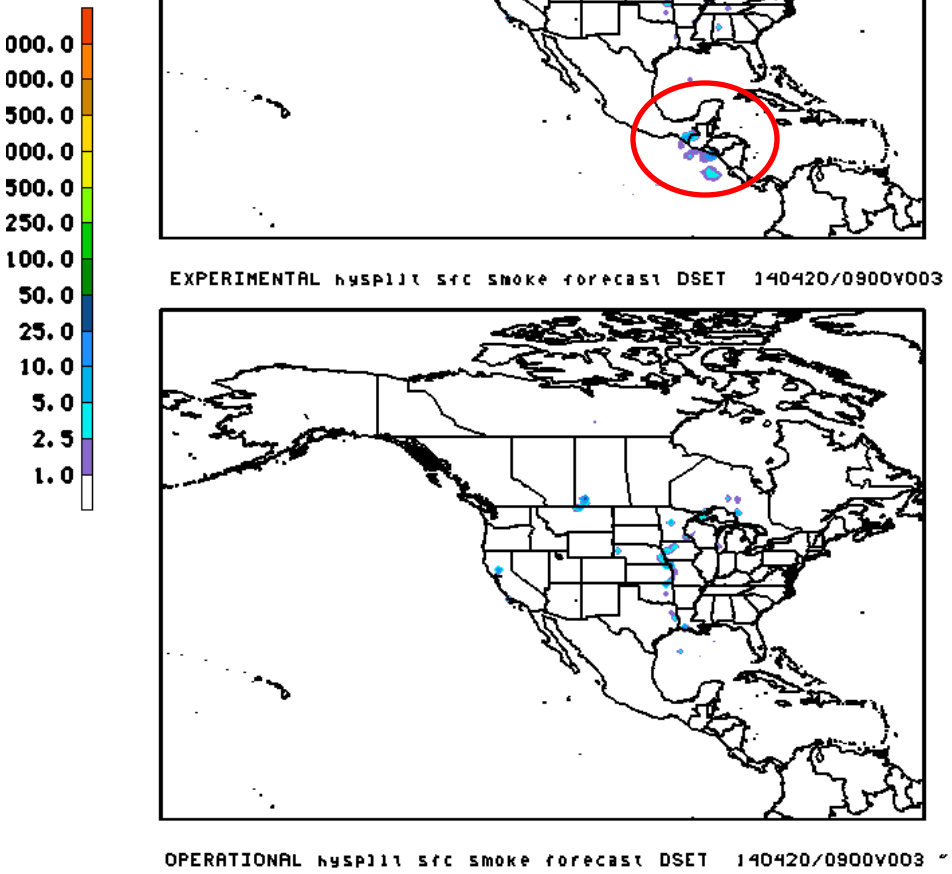
http://www.emc.ncep.noaa.gov/mmb/aq/fvs/hysplit/web/html/fho.html

Using NDFD 5 km G227 model output grid

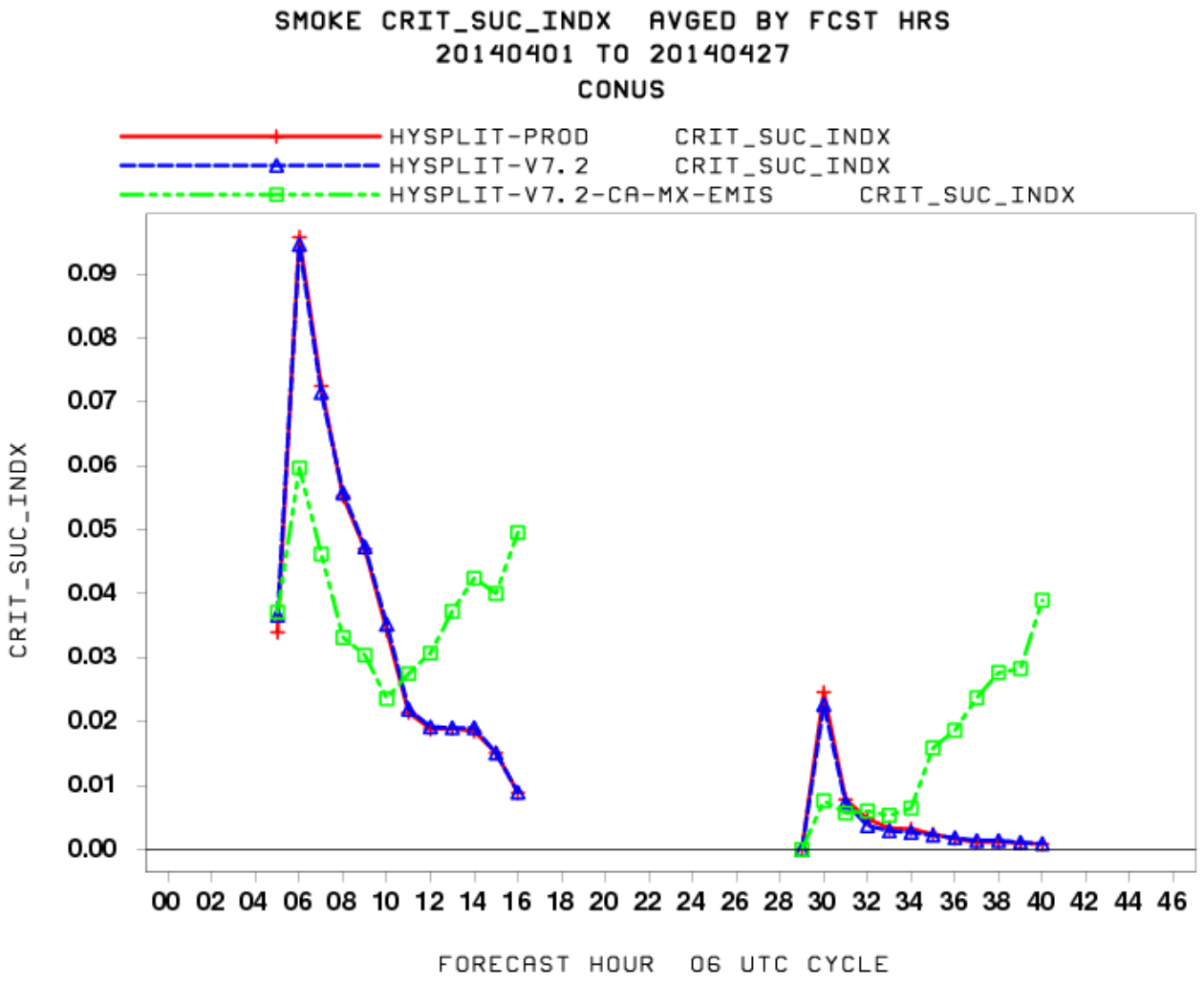
- Good improvements with Canada/Mex emissions

Canada/ Mexico Emission impact

April 20, 2014 Full Domain

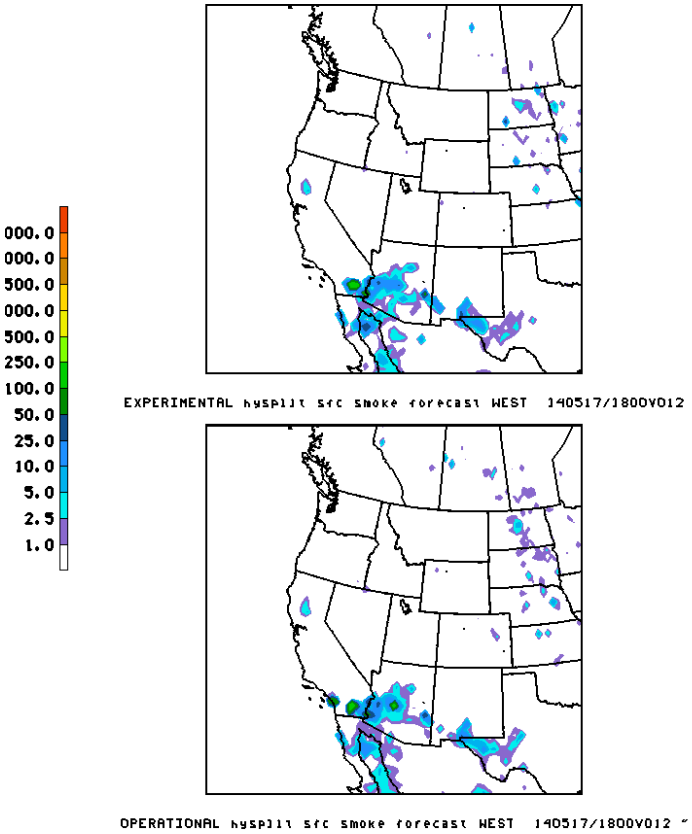


Day 1 vs Day 2 smoke predictions



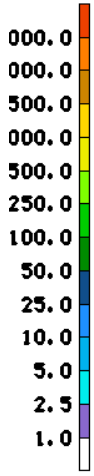
Smoke Application Summary

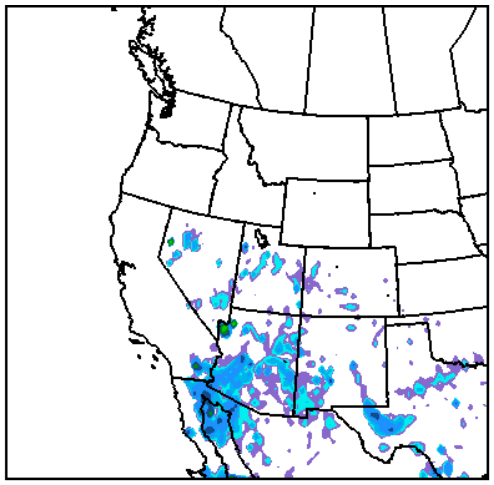
- Use of Canadian and Mexican emissions yields improved forecasts for real-time and retrospective HYSPLIT simulations
- Recommend implementation given the relative importance of higher smoke concentrations on human health.



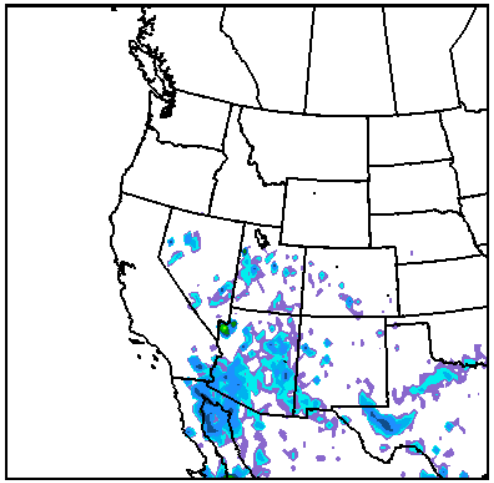
May 17, 2014 Smoke forecast

HYSPLIT Dust Application

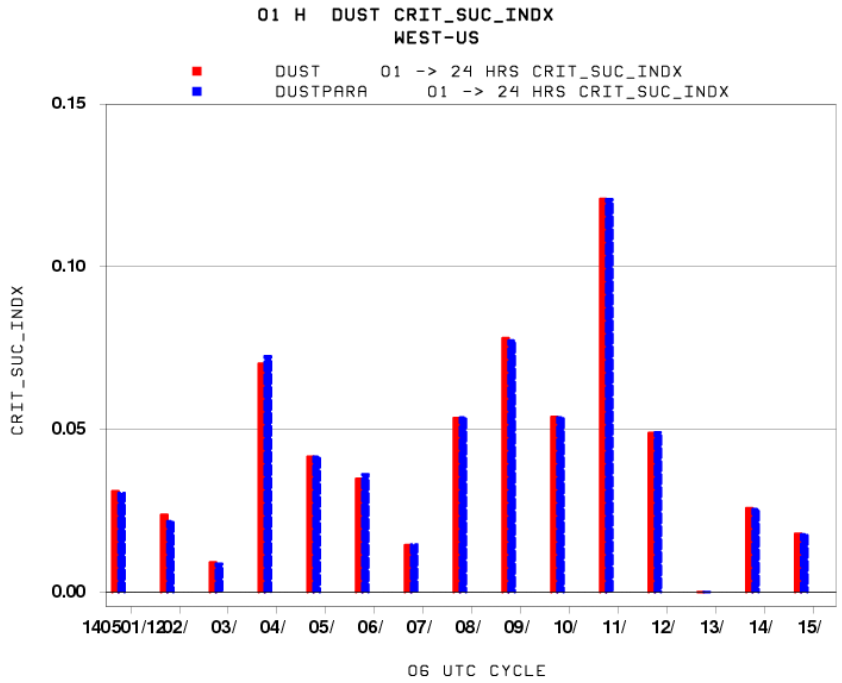




EXPERIMENTAL hysplit sfc dust forecast WEST 140517/21



OPERATIONAL hysplit sfc dust forecast WEST 140517/210(



Comprehensive Test Ban Treaty Organization back-tracking

CTBTO

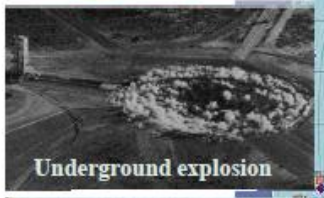
CTBTO PREPARATORY COMMISSION

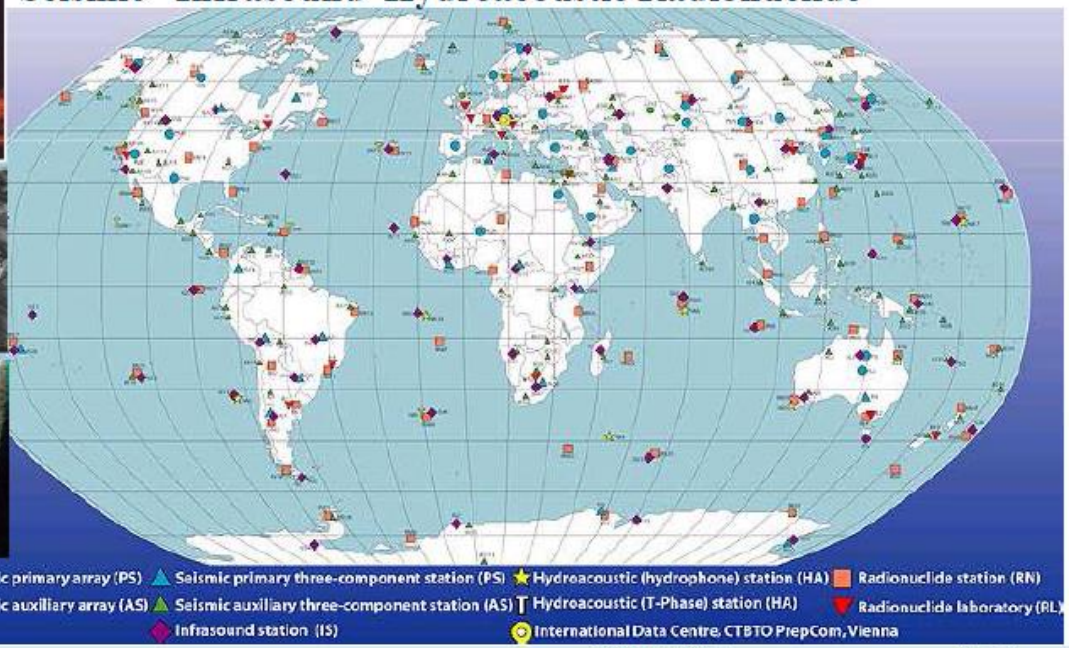
CTBT (**Comprehensive Nuclear-Test-Ban Treaty**) bans all nuclear explosions

CTBTO(Comprehensive Nuclear-Test-Ban Treaty Organization) operates a system (International Monitoring System) monitoring compliance with the CTBT

Monitoring based on four technologies

Seismic Infrasound Hydroacoustic Radionuclide



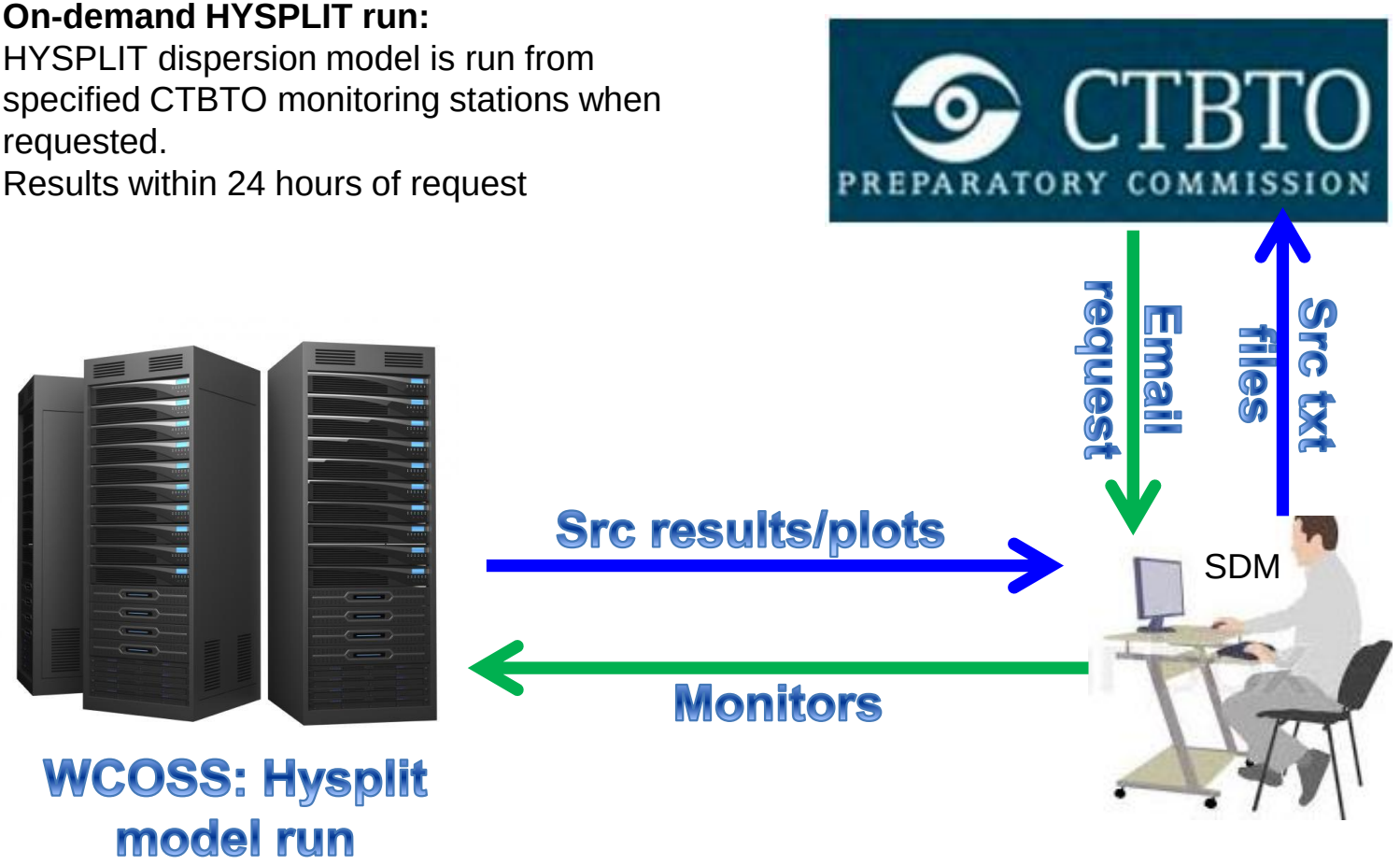


CTBTO 22 February2012 Page 3

Courtesy CTBTO, Vienna, Austria

CTBTO overview

On-demand HYSPLIT run:
HYSPLIT dispersion model is run from specified CTBTO monitoring stations when requested.
Results within 24 hours of request



- SDM/SOS transfers input request file for processing to WCOSS
- Typically 7-10 different receptor locations and/or receptor times
- GDAS (1 degree 6 hrly) 30 day rotating archive to drive back-tracking
- WCOSS output text and graphics transferred to NCO server

Source-Receptor Relationship

- Source Receptor Sensitivity (SRS) field M_{kijn} or retro-plume or dilution factor field [m^{-3}] is specific to each radionuclide sample

- A retro-plume is simulated by running an atmospheric transport model backward in time with "releases" corresponding to radionuclide samples

- SRS translates any **grid point** release at position *i,j* and transport time from source to receptor *n* [Bq] into the activity concentration c_k [Bqm^{-3}] for the *kth sample* :

$$c_k = M_{kijn} \cdot S_{ijn}$$

A CTBTO Request (9/4/13)

- …
- ==========
- Source-receptor matrix results are requested for
- 007
- stations
- # LON LAT ID Measurement Start/stop time (YYYYMMDD hh)
- 001 139.08 36.30 JPP38 20130828 06 20130829 06
- 002 139.08 36.30 JPP38 20130829 06 20130830 06
- 003 132.00 44.15 RUP58 20130829 03 20130830 03
- 004 127.90 26.50 JPP37 20130829 00 20130830 00
- 005 158.79 53.06 RUP60 20130829 00 20130830 00
- 006 144.93 13.57 USP80 20130829 06 20130830 06
- 007 139.08 36.30 JPP38 20130830 06 20130831 06
- ==========
- Please calculate backward to
- 20130820 00
- ==========
- Please upload data within
- 24
- hours
- ==RESPONSE FORM==========
- === WMO Centre response form ===
- === Please send back this form ===
- === to the sender of the request as ===
- === soon as possible ===
- ==========

- (x) We will send our contributions within the time limit (default)
- ( ) We will send our contributions kkk hours later then the time limit
- ( ) We got your request but are not able to perfom computations
- ==========

- ====== PTS REQUEST FOR SUPPORT ===== THIS IS NO EXERCISE !!!

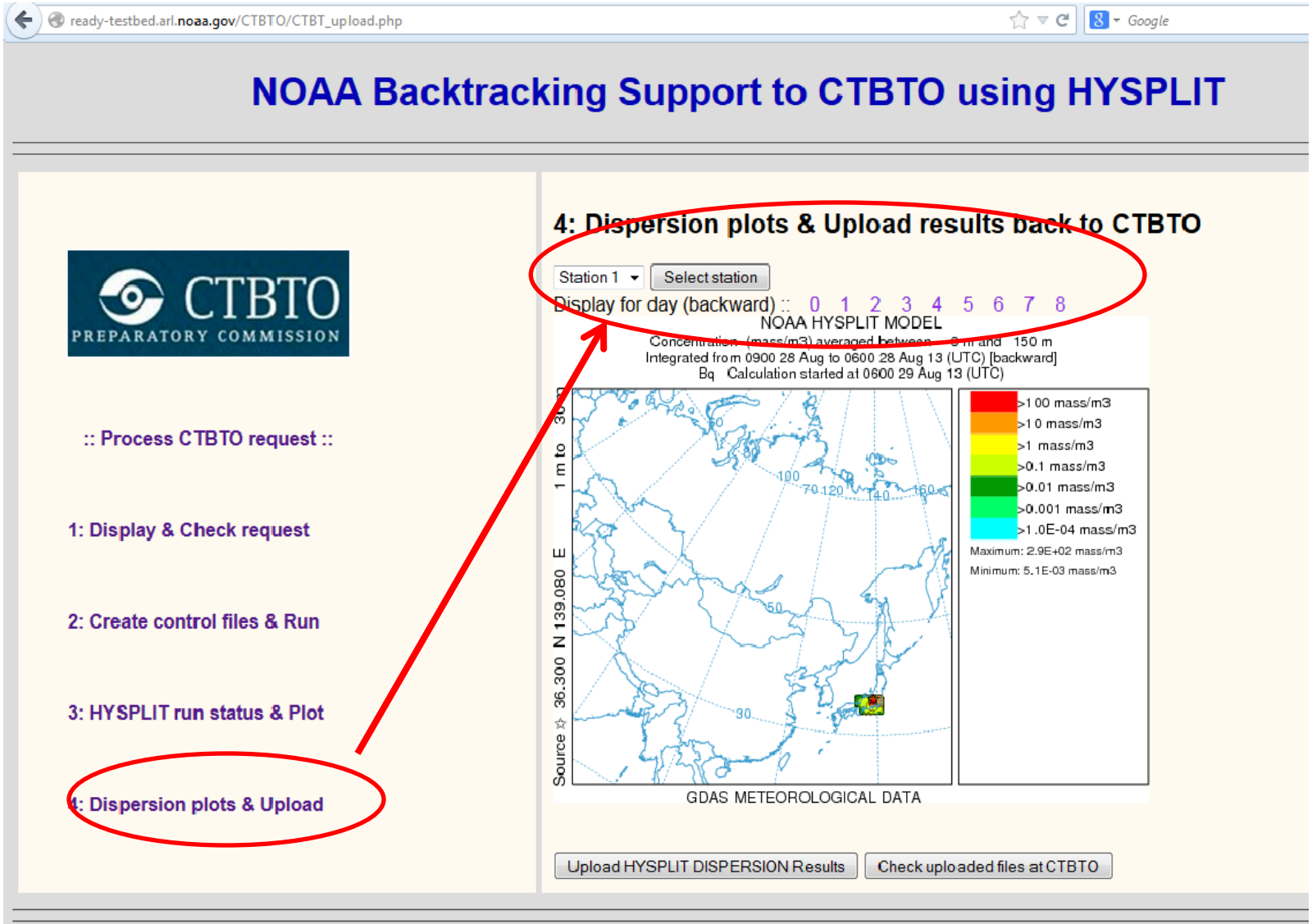
CTBTO Monitor in Australia

7 SRS results requested for measurements:

- Station lat/lon measurement start/stop time
- Calculate backwards to target time (2013/8/20 00Z)

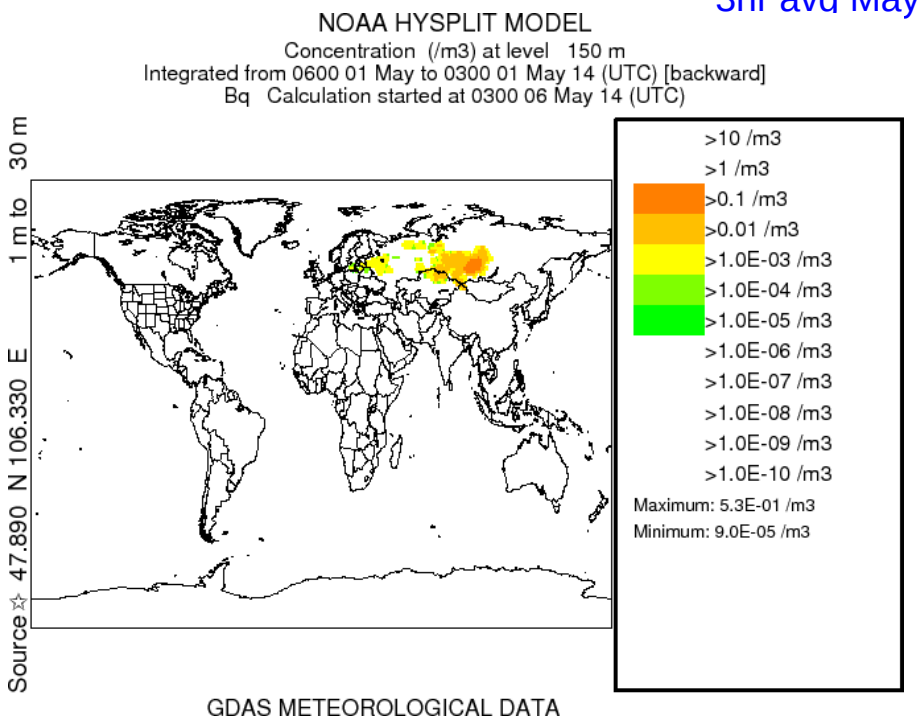
Dispersion plots uploaded to SDM server

- Plots for each station can be displayed on different days.
- Available plots for the selected station are listed after “Display for day (backward)”.

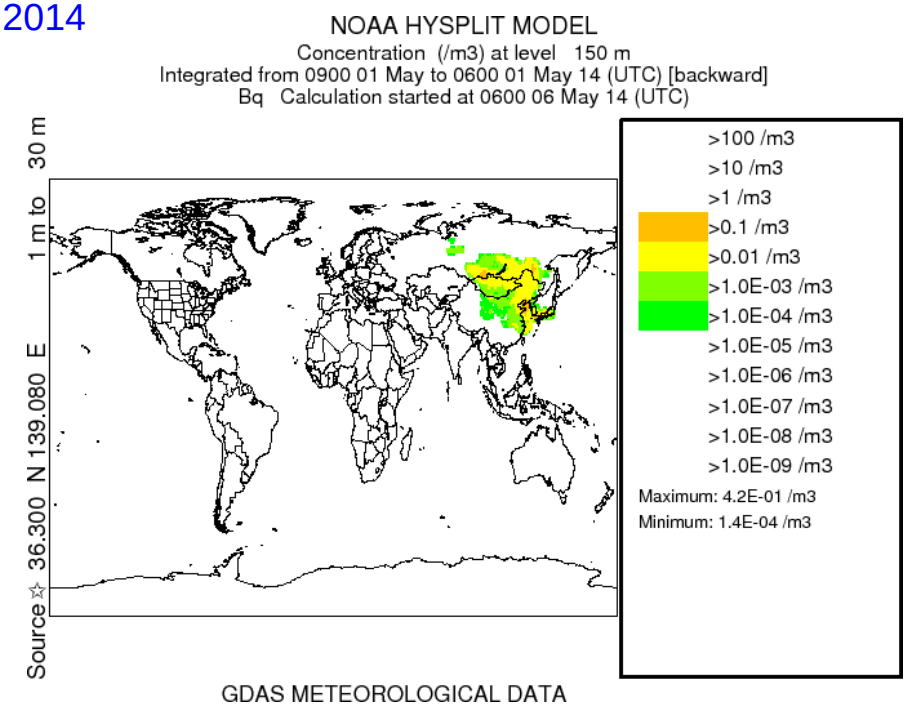


CTBTO Backward Integrated Concentrations Diagnostic Graphics

3hr avg May 1, 2014



RUP58 3Z May 6, 2014 receptor backtrack



JPP38 6 Z May 6, 2014 receptor backtrack

Created as part of WCOSS CTBTO run
Transferred to SDM server for evaluation

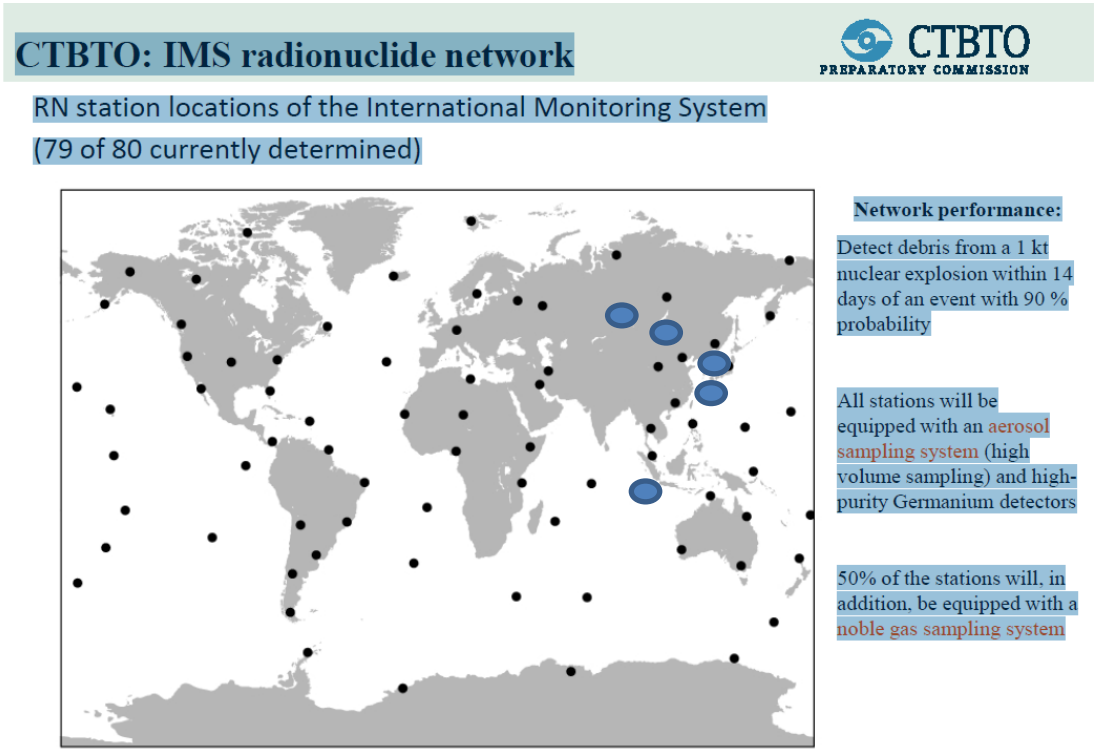
1. JPP38 : 36.30, +139.08 , 06Z 5/5/2014
2. JPP38 : 36.30, +139.08 , 06Z 5/6/2014
3. RUP58: 44.15, +132.00 , 03Z 5/6/2014
4. JPP37 : 26.50 , +127.90 , 00Z 5/6/2014
5. USP80 : 13.57, +144.93 , 06Z 5/6/2014
6. RUP60 : 47.89,+ 106.33 , 03Z 5/6/2014
7. JPP38 : 36.30, +139.08 , 06Z 5/7/2014

CTBTO Final product

Ascii concentration files transferred to CTBTO

Ascii conc file from each measurement initial condition (lat/lon/measurement duration)

- 139.08 36.30 **20140504 06 20140505 06** 0.13E+16 222 3 3 1.00 1.00 **"JPP38"**
- 36.00 139.00 1 0.3087454E+02
- 36.00 139.00 2 0.1008972E+03
- 36.00 140.00 2 0.2212261E+01
- 36.00 139.00 3 0.1529966E+03
- 35.00 140.00 3 0.4553059E+00
- 36.00 140.00 3 0.6934483E+02
- 35.00 139.00 4 0.9103926E+00
- 36.00 139.00 4 0.2370508E+03
- 35.00 140.00 4 0.1629736E+02
- 36.00 140.00 4 0.7261011E+02
- 35.00 139.00 5 0.5423383E+01
- 36.00 139.00 5 0.3232218E+03
- 34.00 140.00 5 0.3527995E-01
- 35.00 140.00 5 0.4756739E+02
- 36.00 140.00 5 0.2613296E+02
- 35.00 139.00 6 0.2511884E+02
- 36.00 139.00 6 0.3543827E+03
- 34.00 140.00 6 0.3757222E+01
- 35.00 140.00 6 0.4828796E+02
- 36.00 140.00 6 0.1101647E+01
- 34.00 141.00 6 0.1978191E+00
- 34.00 139.00 7 0.4536643E-01
- 35.00 139.00 7 0.7709255E+02
- .....
- .....



PROPOSED EVALUATION TEAM

Organization	Recommended	Optional (nice to have)
NCEP Centers	EMC, NCO	
NCEP Service Centers	SDM, SPC,AWC	
NWS Region / WFO	ER, CR, SR, WR, AR, Pac	
Other NWS or NOAA components	OST	
External Customers / Collaborators	Washington and Anchorage VAACs + Hi MWO, CTBTO	CMC Canada & NHMC RSMCS for radiological atmospheric dispersion

PROPOSED EVALUATION TEAM

Organization	Recommended	Individual	HYSPLIT Applications
NCEP Centers	EMC ARL NCO	Jianping Huang Barbara Stunder C. Caruso	ALL : smoke, dust, volcanic ash, Radiological & RSMC, Hazmat, CTBTO
NCEP Service Centers	SDM SPC AWC	Joe Carr E; Leitman _____	Ash, RSMC, CTBTO, Hazmat Smoke, Dust Ash, RSMC
NWS Region / WFO	ER CR SR WR AR Pac	Jeff Waldstriker Jeff Craven Andy Edman Neil Petreskew Roger Edson	Hazmat, Ash, Smoke, Dust Hazmat, Ash, Smoke, Dust Hazmat, Ash, Smoke, Dust Hazmat, Ash, Smoke, Dust Hazmat, Ash, Smoke Hazmat, Ash
Other NWS or NOAA components	OST NESDIS Washington VAAC Anchorage VAAC HI MWO	Ivanka Stajner Mark Ruminski Grace Swanson Don Moore	Smoke, Dust, CTBTO Smoke, Dust, Ash Volcanic Ash Volcanic Ash
External Customers / Collaborators	CTBTO USFS (smoke) WMO (RSMC)	Monica Krysta Susan O'Neil Peter Chen	

JOB / RESOURCE REQUIREMENTS

New executables, jobs, and scripts

- Primarily CTBTO:

~/jobs
JHYSPT_CTBTO_CHK, JHYSPT_CTBTO_FCS, JHYSPT_CTBTO_POST

~/scripts (.sh.ecf) *UPDATE*: exhysplit_prep
exhysplit_ctbto_request_chk, exhysplit_ctbto_fcst, exhysplit_ctbto_post

~/sorce hysplit_set4ctbt.fd, hysplit_con2ctbt.fd

~/exec hysplit_set4ctbt, hysplit_conc2ctbt;
UPDATE: hysplit_hycsst, hysplit_concplot, etc…

~/fix ctbto_ascdata.cfg, ctbto_setup.cfg, ctbto_arlmap

- ARL Hysplit library update
- Extend ARL formatted GDAS files from 7 to 30 day rotating archive
- ½ degree GFS ARL-Packed format file for Volc Ash (hysplit_global2arl)
- New capability : CTBTO source attribution run with text output
  - 1 additional node for around 60 minutes for 10 sites
- NCO web server capability : For invoking CTBTO run and evaluating output

EE READINESS

- HYSPLT V7 already uses vertical structure
  - /nwprod/hysplit.v7.0.2

PRODUCT CHANGES

HYSPLIT currently generates:

- 12 km hourly smoke and dust grib files for surface and column levels
  Displayed at NDGD
- Volcanic ash grib file, RSMC dispersion graphics
- DHS/HAZMET graphics

- **Changes:**
  - CTBTO ascii source probability text file and graphics
    - WCOSS files/graphics → NCO web server → CTBTO
    - SDM reviews before transmission to CTBTO
    - NOTE: CTBTO Products to remain internal to NCO & CTBTO
  - GRIB2 smoke/dust/volcanic ash output files instead of GRIB1

Analysis of New Product Volume

Disk Usage	Current Production	Expected New Production	Actual New Production
IBM Disk	724.1 GB/day	+9 GB - CTBTO +6 GB - ½ ° GFS	-
IBM Tape	similar minimal	change	-
NCEP FTP Server	similar minimal	+6 GB ; ½ ° GFS ARL Packed file	-
NWS FTP Server	similar minimal	No change	-

DEPENDENCIES

UPSTREAM: GFS, NAM, RAP,
NESDIS HMS smoke locations,
USFS Bluesky emissions

DOWNSTREAM: NDGD (smoke, dust), NAWIPS (Volc. Ash), ARL RSMC radiological web graphics page, WOC HAZMAT

Upstream dependency requires following enhancements:

1. CTBTO input file transmission to WCOSS from NCO server.
   - Run then invoked by SOS on WCOSS
2. HYSPLIT Tested with Production GFS ,NAM, RAP

Downstream dependency requires following enhancements:

1. Transfer CTBTO ascii file & graphics from WCOSS to NCO server and then to CTBTO after SDM review.
2. Transfer RSMC radiological text to MWOs (AWC, HI, AK).

TIN: To be prepared and issued by or before August

NAQFC : HYSPLIT Dispersion Model
Project Status as of 5/14/2014

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Project Information and Highlights

Lead: Jeff McQueen, Jianping Huang, EMC, Barbara Stunder, ARL, Chris Magee, NCO

Scope:

1. Meteo Prep

– extend retention of GDAS hysplit format files in /com/hysplit to 30 days

- Add ½ degree GFS hysplit format files

2. CTBTO – new application & web GUI for model configuration
3. On-demand SDM Hysplit runs (volc. ash, RSMC, DHS)
   - Output and processing of grib2 instead of grib1
   - Graphics bug fixes
   - Transfer RSMC radiological text product to MWOs (AWC, Anchorage and Honolulu).
4. Smoke/dust/ash

–- Include Canadian & Mexican smoke emissions for smoke application

5. All: Update to unified HYSPLIT code and libraries

Expected Benefits:

1. Meet NWS, CTBTO, WMO, ICAO, FAA, DHS requirements.
2. Consistent Hysplit executables, libs for all applications
3. Higher res met for volc. Ash/ RSMC response

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Issues/Risks

Issues:

- Major upgrade : New capability
- NCO to lead transition of CTBTO web pages

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- **Mitigation:**
- Delay implementation of capabilities

Scheduling

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Milestone (NCEP)	Date	Status
EMC-NCO Kickoff Meeting	01/29/2014	Update on 2/11/14
EMC HYSPLIT upgrades complete	03/14/2014	3/1/2014
Hysplit RFCs submitted to NCO	03/17/2014	4/16/2014
Technical Information Notice Issued	08/15/2014	By or before
Initial Test Complete		
CCB approve parallel data feed		TBD
IT testing begins		TBD
IT testing ends		TBD
Parallel testing begun in NCO	June, 2014	For CTBTO component
Real-Time Evaluation Ends	09/02//2014	
NCEP OD Management Briefing	09/09/2014	Or before for non-CTBTO
Operational Implementation	09/16/2014	Or before for non-CTBTO

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Finances

Associated Costs: CTBTO funding; NAQFC funding, Mission

Funding Sources: EMC : T2O 4 man-months

NCO Base:

2 man-months for CTBTO development

2 man-months for implementation,

1 man-month annually for maintenance

R	Management Attention Required	Y	Potential Management Attention Needed	G	On Target